



UPPER RAPPAHANNOCK RIVER BACTERIA TMDL DEVELOPMENT

Virginia Department of Environmental Quality
Rappahannock-Rapidan Regional Commission
Engineering Concepts, Inc.

FIRST PUBLIC MEETING
October 17, 2006



QUESTIONS TO ANSWER

- What is the history of the watershed?
- Who/what is producing bacteria in the watershed?
- How much bacteria is being produced by sources in watershed?
- How is the bacteria reaching the stream?
- What source reductions are needed to meet the water quality standard?



TMDL DEVELOPMENT PROCESS

● WATERSHED HISTORY

- Characterize watershed and identify critical contamination conditions

● SOURCE ASSESSMENT

- Identify and quantify pollutant sources

● MODELING

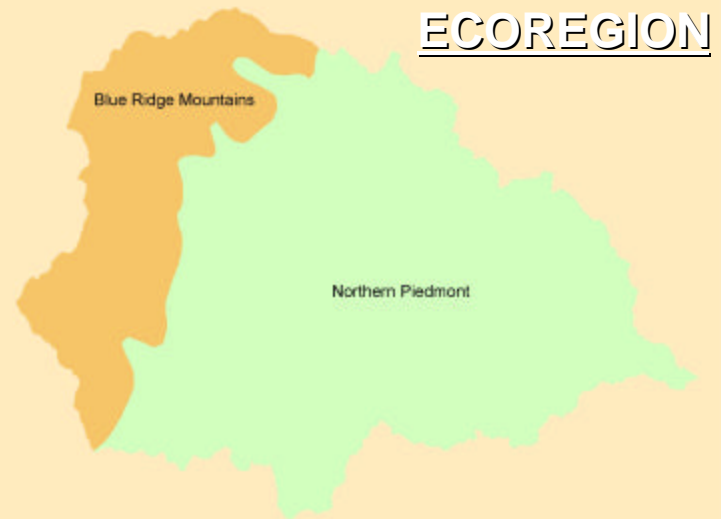
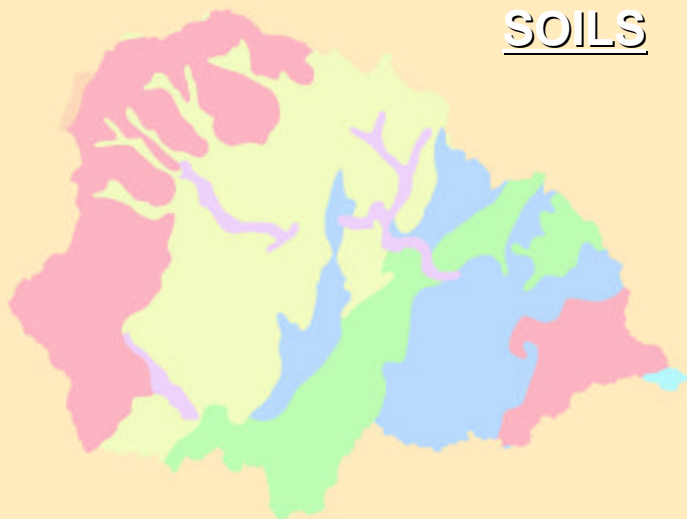
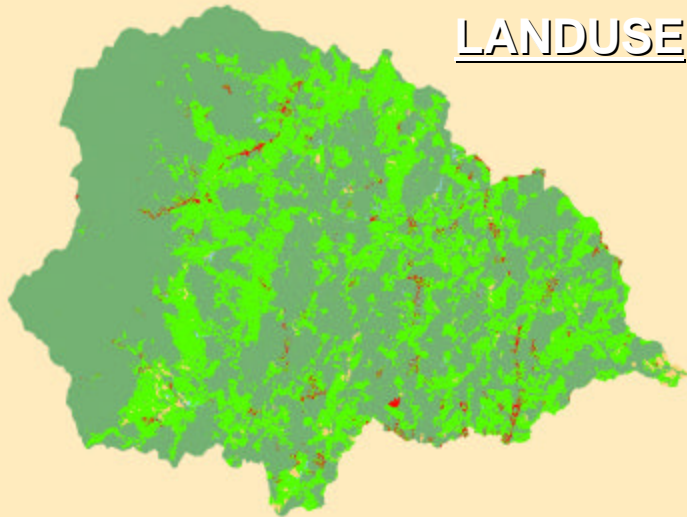
- Link pollutant sources to stream water quality

● ALLOCATION

- Develop and evaluate allocation scenarios



WATERSHED CHARACTERISTICS





WATERSHED CHARACTERISTICS

Impairment	Drainage Size (sq. mi.)	Land use			
		Agricultural (%)	Residential (%)	Forest (%)	Water (%)
Hazel River (60076)	316	32	<1	67	<1
Rappahannock River (VAN-E08R-04)	619	36	1	63	<1
Rappahannock River (60081)	641	37	1	62	<1
Craig Run (VAN-E08R-03)	8	70	6	24	<1
Browns Run (VAN-E08R-02)	11	50	2	47	1
Marsh Run (VAN-E08R-01)	46	55	3	41	1

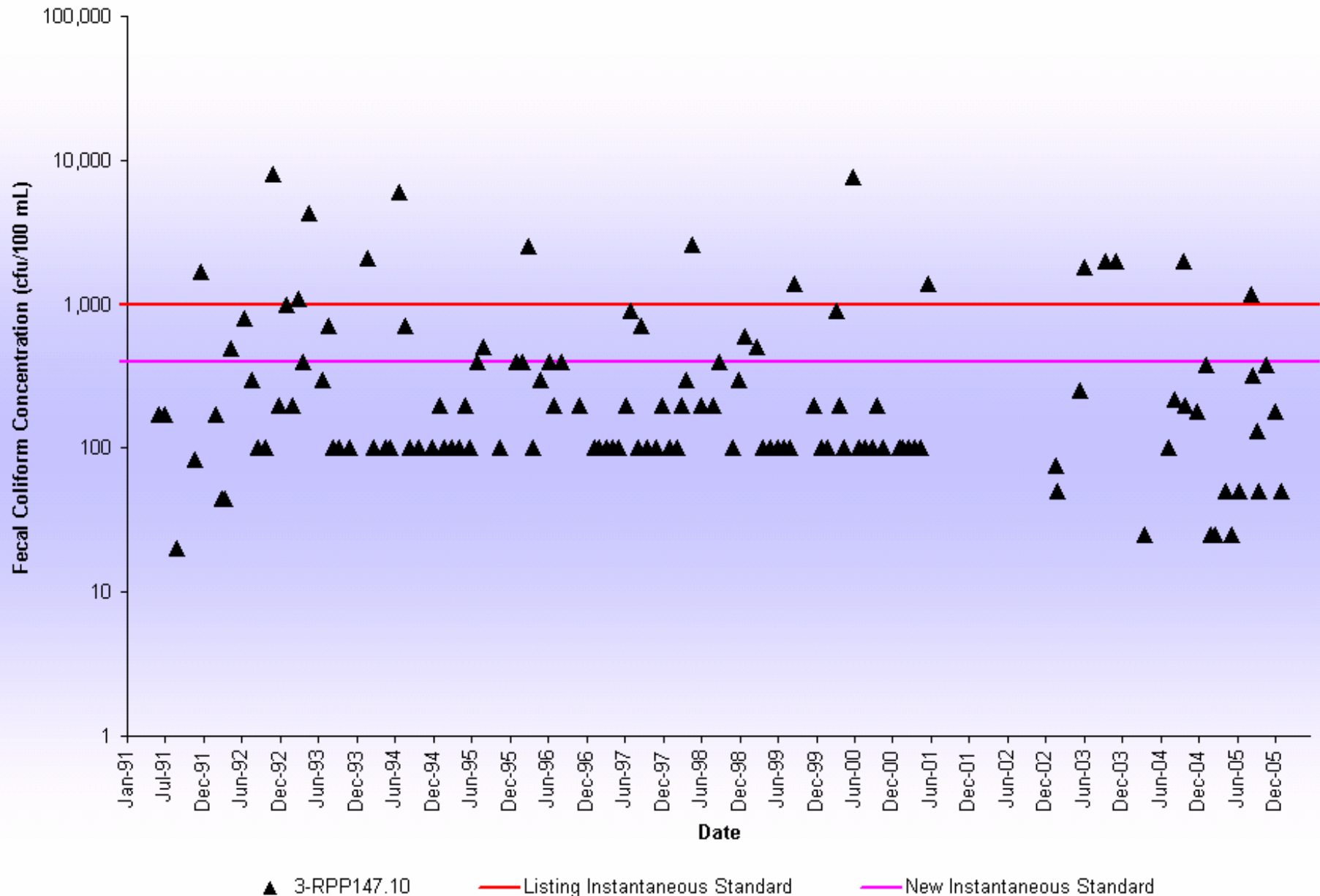


WATERSHED HISTORY

- Identify critical contamination conditions
 - Timeseries of bacteria concentration
 - Seasonality
 - Bacteria concentration versus flow

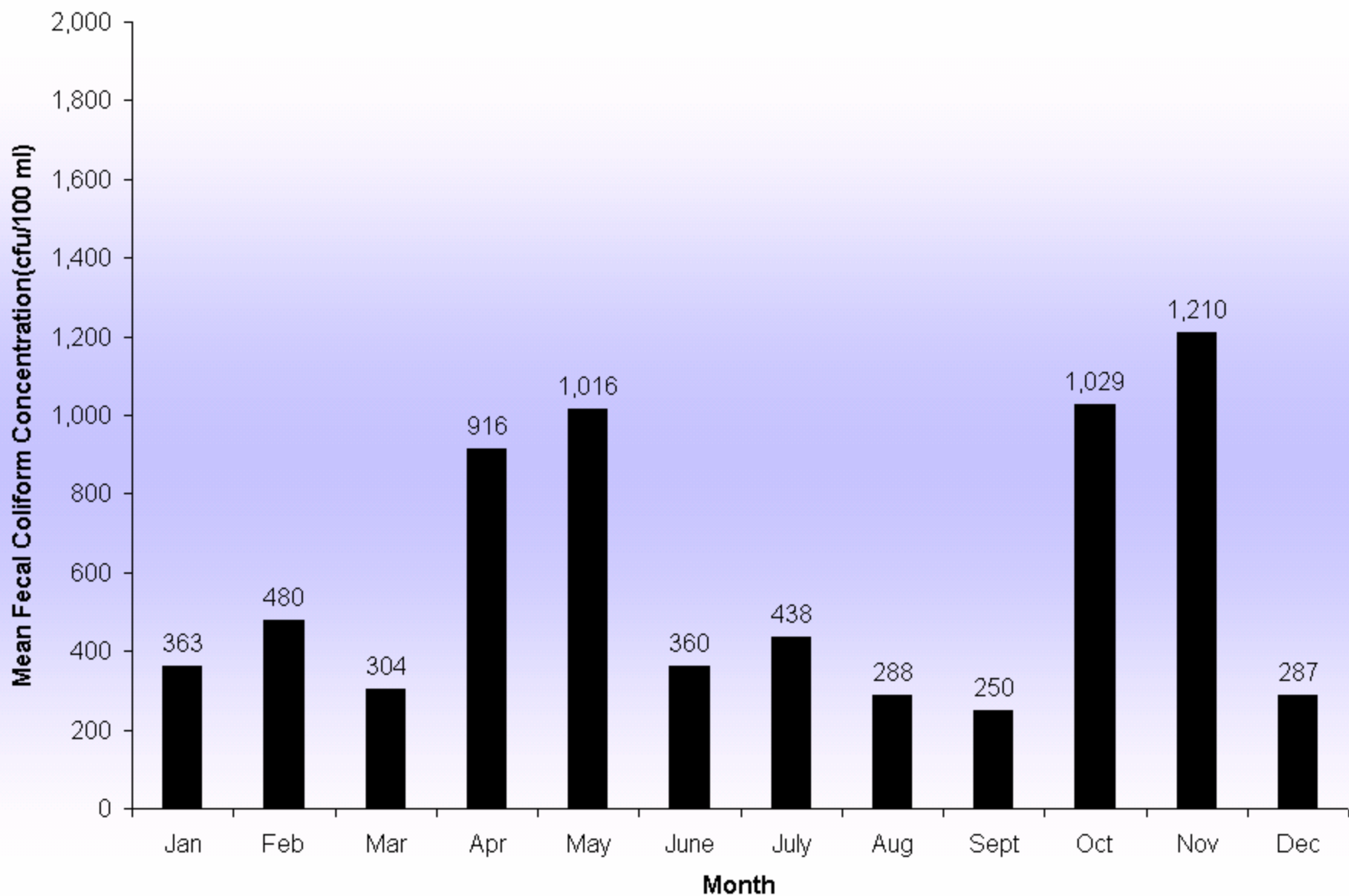


BACTERIA TIMESERIES



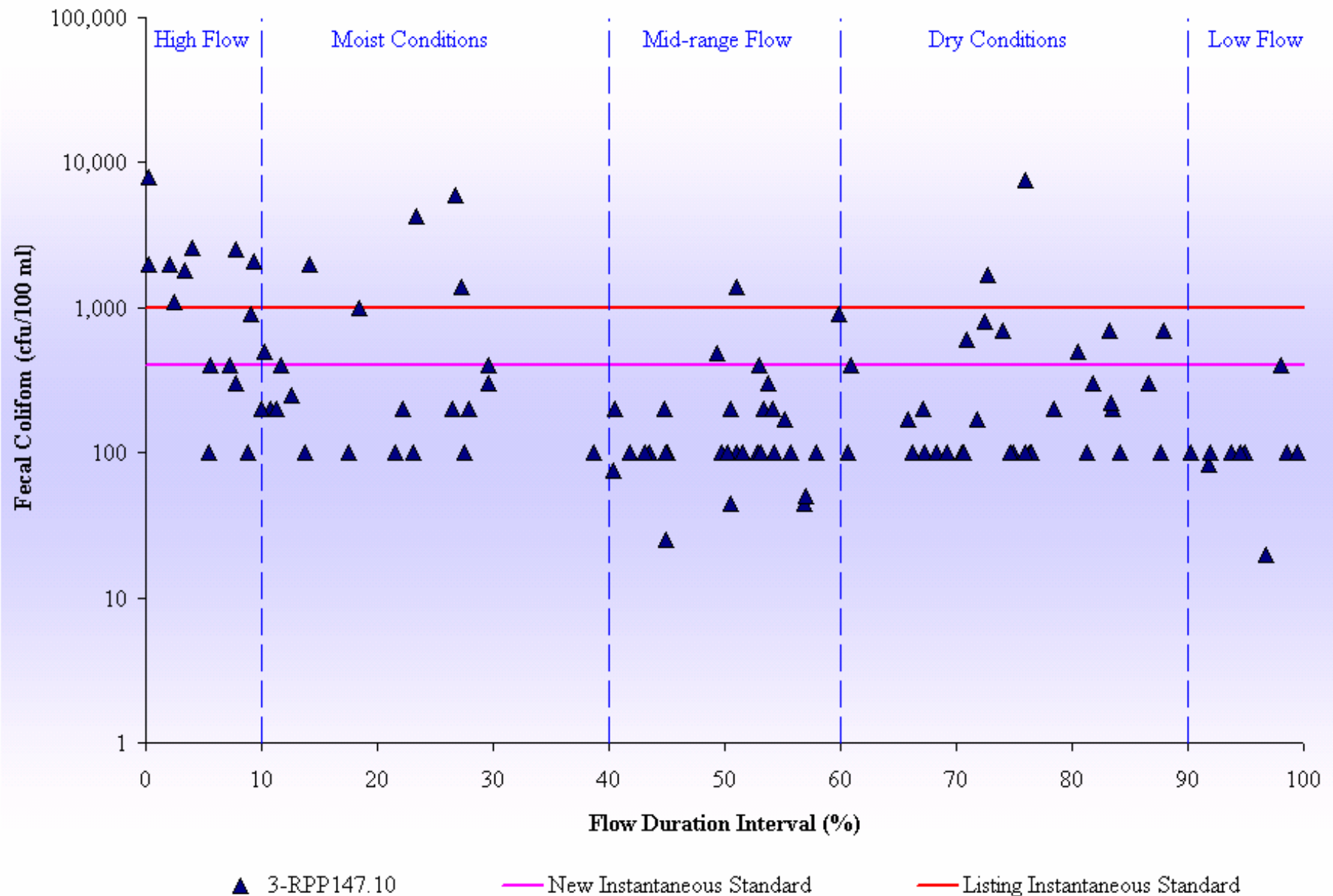


BACTERIA SEASONALITY





BACTERIA VS. FLOW



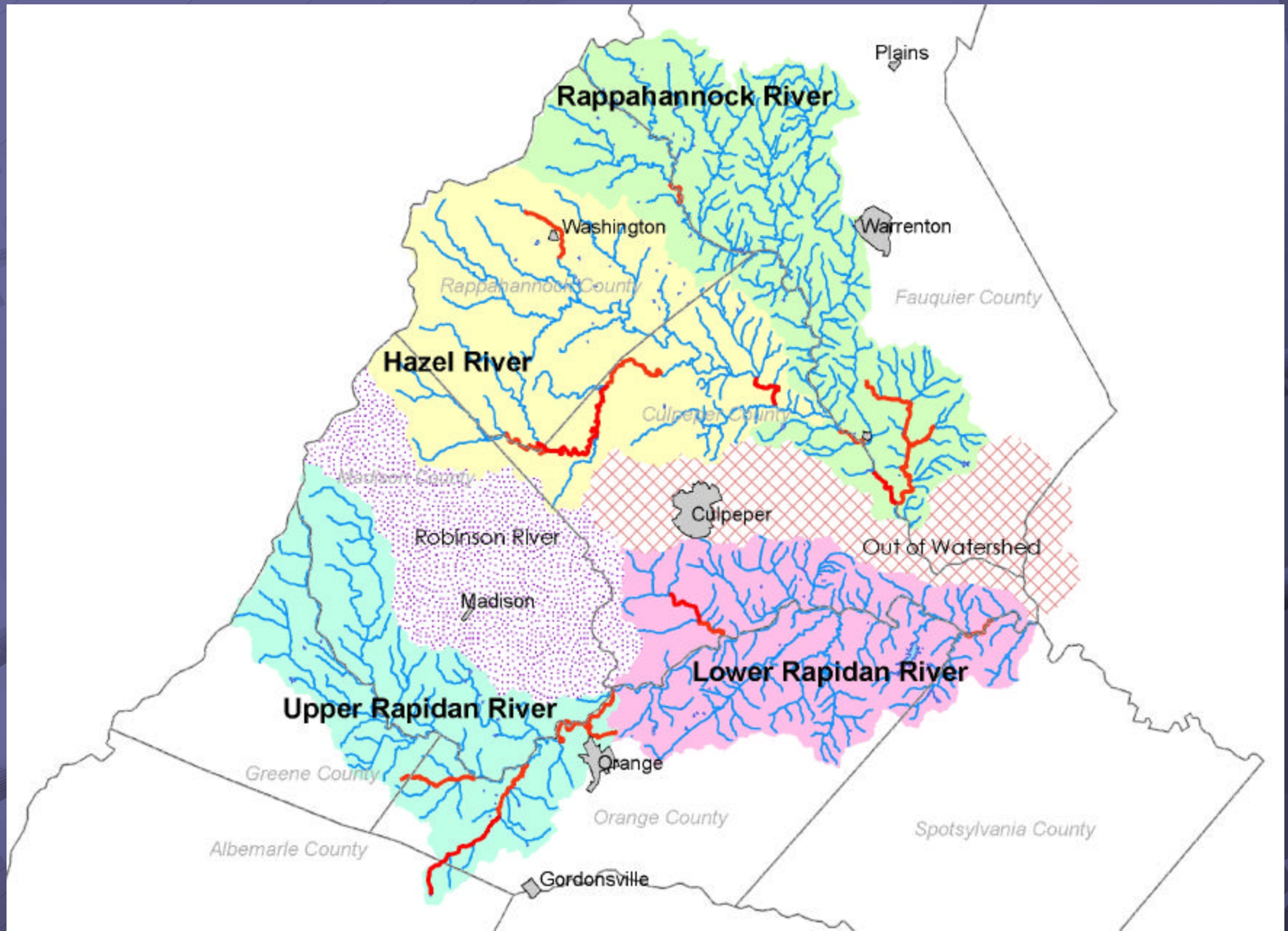


SOURCE ASSESSMENT

Source Category	Source / Animal Type
Human and Pets	Permitted Discharges
	Sanitary Sewer
	Straight Pipes
	Failing Septic Systems
	Biosolids Applications
	Dogs / Cats
Agricultural	Dairy & Beef Cattle
	Horses
	Sheep
	Chicken
	Turkey
Wildlife	Deer
	Raccoon
	Muskrats
	Beavers
	Turkeys
	Geese
	Ducks



MODEL REGIONS





RAPPAHANNOCK SUBWATERSHEDS





HAZEL RIVER SUBWATERSHEDS





PERMITTED POINT SOURCES

- Virginia Pollution Discharge Elimination System
 - Types - municipal, industrial, general
 - Categories – major, minor, general





PERMITTED DISCHARGES

Impairment	Facility Type (#)			Design Flow (MGD)	
	Municipal	Industrial	General	Minimum	Maximum
Hazel River (60076)	6	1	5	0.001	0.060
Rappahannock River (VAN-E08R-04)	14	1	8	0.001	2.500
Rappahannock River (60081)	16	1	8	0.001	2.500
Craig Run (VAN-E08R-03)	0	0	0	N/A	N/A
Browns Run (VAN-E08R-02)	0	0	5	0.001	0.001
Marsh Run (VAN-E08R-01)	0	0	11	0.001	0.001



HUMAN SOURCES

- Population, houses, onsite treatment system based on U.S. Census Bureau, municipality, & E-911 data
- Sanitary sewer
 - Loading type
 - Overflows & exfiltration
 - Land-based / direct deposition
 - Loading type
 - Proximity to stream





HUMAN SOURCES

● Failed septic systems

- Failure to soil surface throughout year
- Failure rate based on age of home

● Straight pipes

- Direct continuous input to stream
- Based on proximity to stream and house age

● Biosolids applications

- Records kept by Virginia Department of Health
- Land-applied



Failed Septic System



Straight Pipe



PET SOURCES

- American Veterinary Medical Association estimates 0.53 dogs and 0.60 cats per household
- Potentially updated through veterinarians, animal control, treasurer, and residents
- $\text{Population} = \text{population density} * \text{houses}$
- Land-based





HUMAN AND PET SOURCES

Impairment	Human Pop. (#)	Housing Unit (#)	Dogs (#)	Cats (#)
Hazel River (60076)	15,286	5,327	2,823	3,196
Rappahannock River (VAN-E08R-04)	36,837	12,170	6,450	7,302
Rappahannock River (60081)	40,128	13,152	6,971	7,891
Craig Run (VAN-E08R-03)	1,836	532	282	319
Browns Run (VAN-E08R-02)	1,148	369	196	222
Marsh Run (VAN-E08R-01)	14,874	5,091	2,698	3,054



LIVESTOCK SOURCES

● Population

- Virginia Agricultural Statistics
- Confined Animal Feeding Operation
- Consultation with SWCD, VADCR, VCE, NRCS, and producers
- Windshield survey



● Distribution of waste

- Confined: waste collected and spread
- Pastured: land-based
- Stream access: direct deposition
- Imported sources



● Seasonal varying applications



LIVESTOCK SOURCES

Impairment	Beef* (#)	Dairy+ (#)	Horse (#)	Sheep (#)	Turkey (#)	Chicken (#)
Hazel River (60076)	9,254	0	3,394	124	0	0
Rappahannock River (VAN-E08R-04)	17,900	620	7,869	452	0	0
Rappahannock River (60081)	18,650	620	8,337	499	0	0
Browns Run (VAN-E08R-02)	317	285	242	16	0	0
Craig Run (VAN-E08R-03)	335	250	255	17	0	0
Marsh Run (VAN-E08R-01)	1,467	815	1,117	73	0	0

* Cow/calf pairs; + Milking herd



WILDLIFE SOURCES

- Populations based on habitat and population densities provided by Virginia Department of Game and Inland Fisheries biologists
- Distribution of waste based on habitat
 - Land-based
 - Direct deposition to stream
- Seasonal variations based on migration patterns and food sources





WILDLIFE SOURCES

Impairment	Deer (#)	Raccoon (#)	Muskrat (#)	Beaver (#)	Geese (#)	Duck (#)	Turkey (#)
Hazel River (60076)	8,482	7,418	17,642	832	1,048	529	558
Rappahannock River (VAN-E08R-04)	16,263	14,656	34,590	1,636	2,142	983	1,187
Rappahannock River (60081)	16,800	15,051	35,881	1,679	2,224	1,012	1,218
Craig Run (VAN-E08R-03)	225	171	753	18	32	11	8
Browns Run (VAN-E08R-02)	308	240	564	26	43	15	22
Marsh Run (VAN-E08R-01)	1,272	996	2,987	109	177	62	77



MODELING

- Link pollutant sources to stream water quality
- Mathematically represent processes that are occurring in the watershed
- Processes
 - Hydrology – water balance
 - Water quality - pollutant fate and transport
- Accuracy Evaluation
 - Based on observed data
 - Flow: USGS gauge = model output
 - Bacteria: VADEQ station = model output

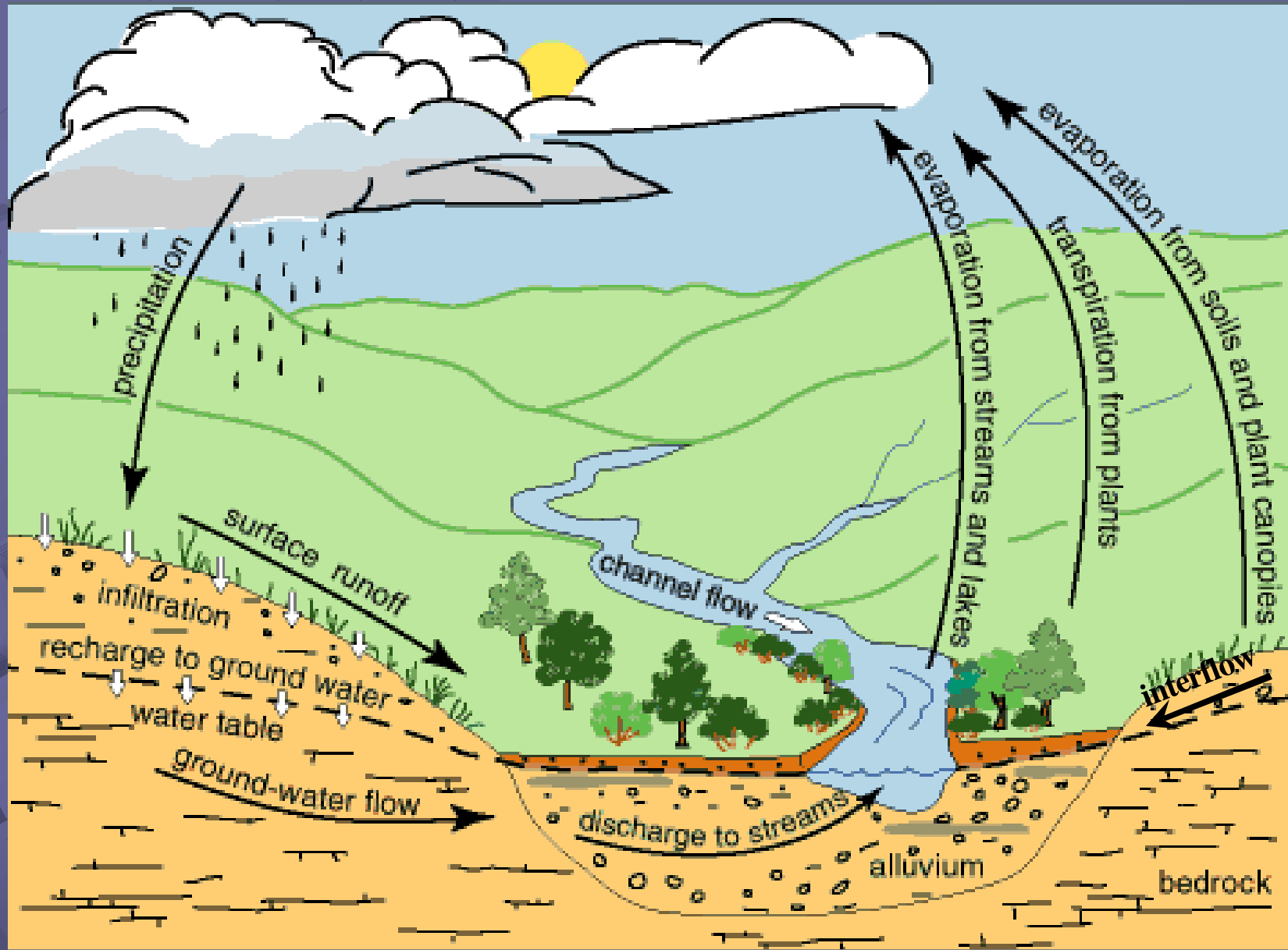


MODELING

- Hydrologic Simulation Program - Fortran
 - Developed by United States Geologic Survey
 - Seasonal patterns in climatic data
 - Simulates point and non-point sources
 - Temporal variations in pollutant loadings

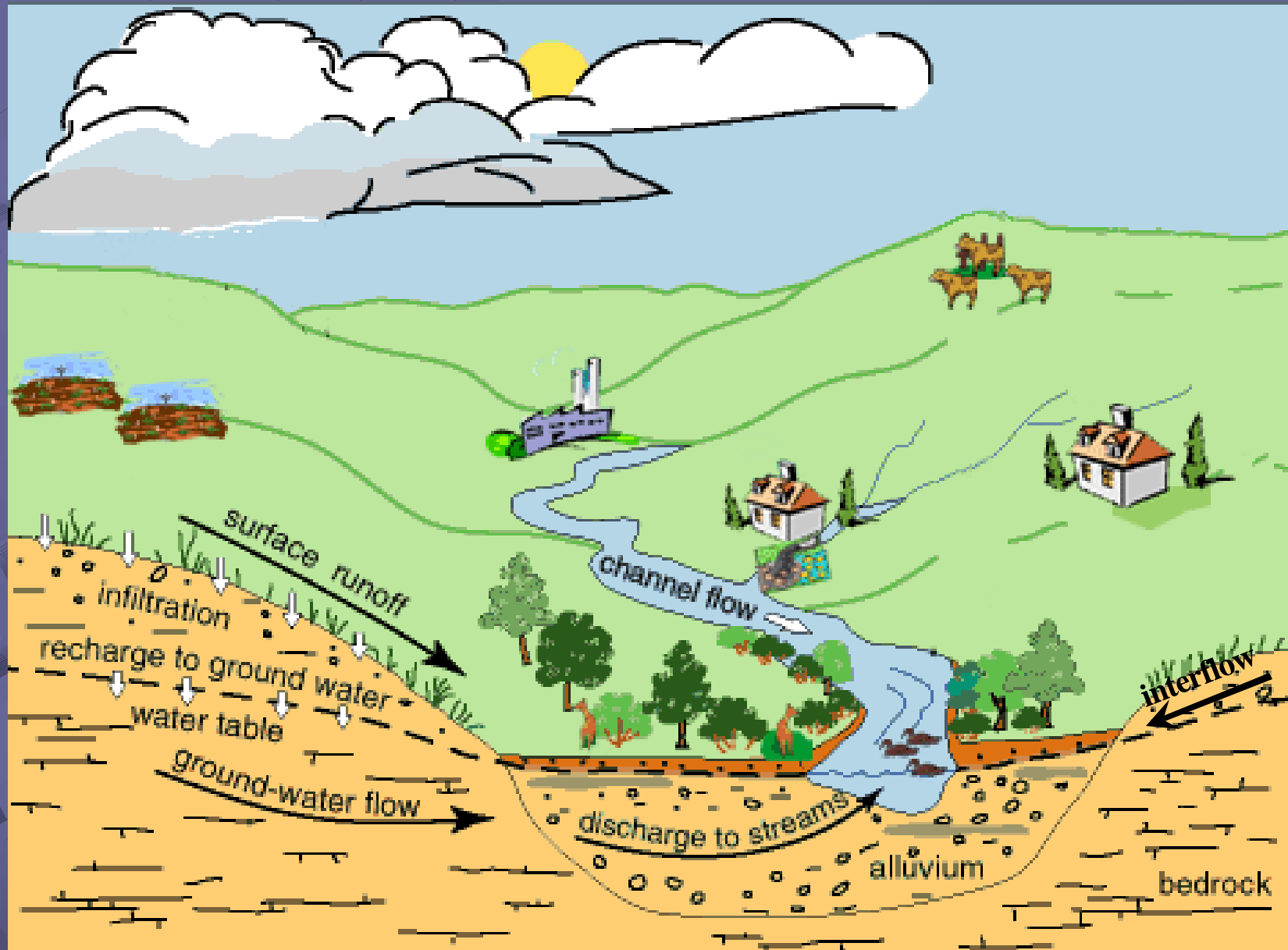


HYDROLOGIC MODELING





WATER QUALITY MODELING





HYDROLOGIC MODELING COMPONENTS

- Climatic data
- Land use
- Topography
- Soils
- Stream channel characteristics
- Point source discharge / withdrawal



WATER QUALITY MODELING COMPONENTS

● Sources

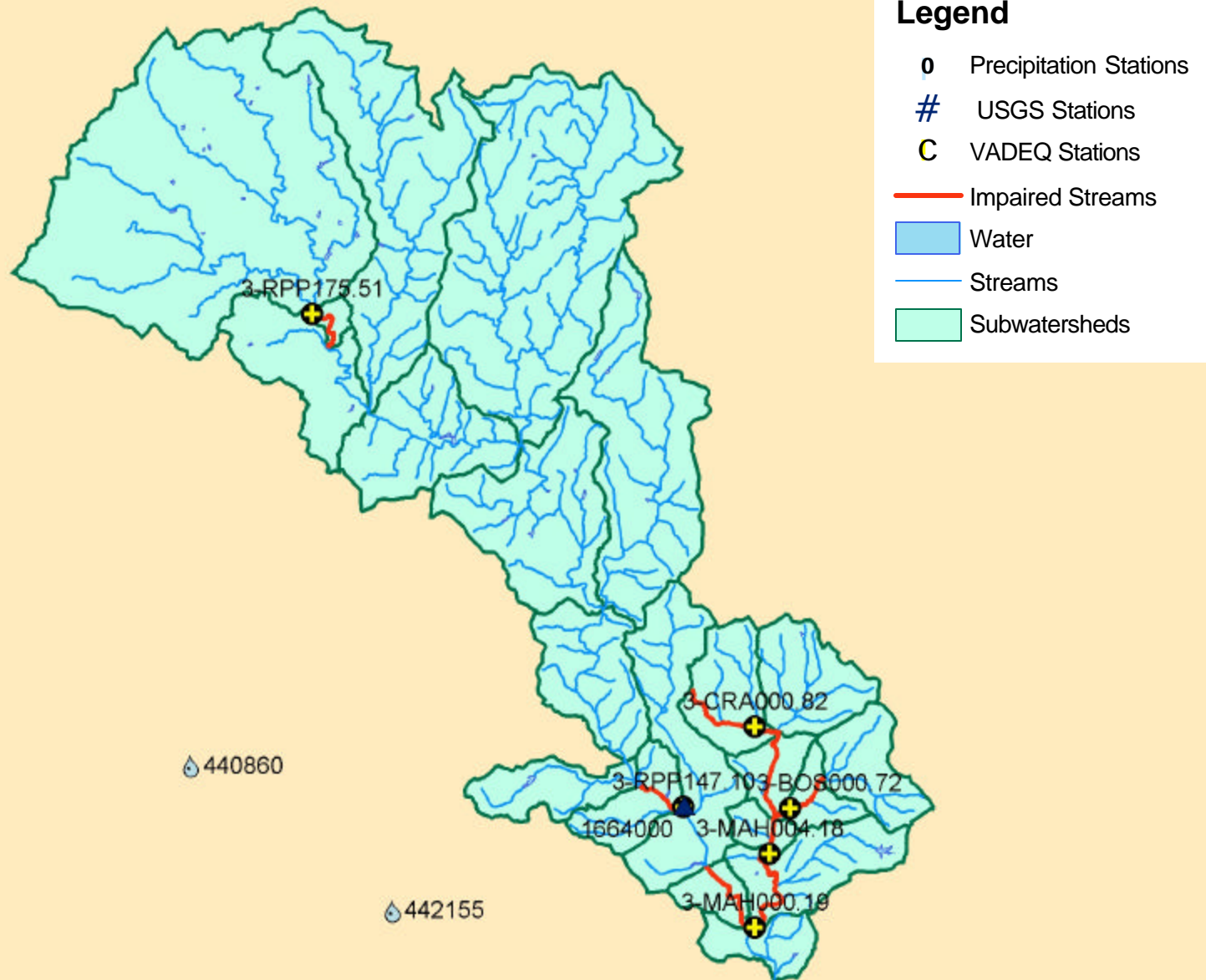
- Fecal production
- Fecal coliform densities
- Fecal coliform distribution
- Fecal coliform temporal variation

● Delivery mechanisms

- Direct
- Land-based

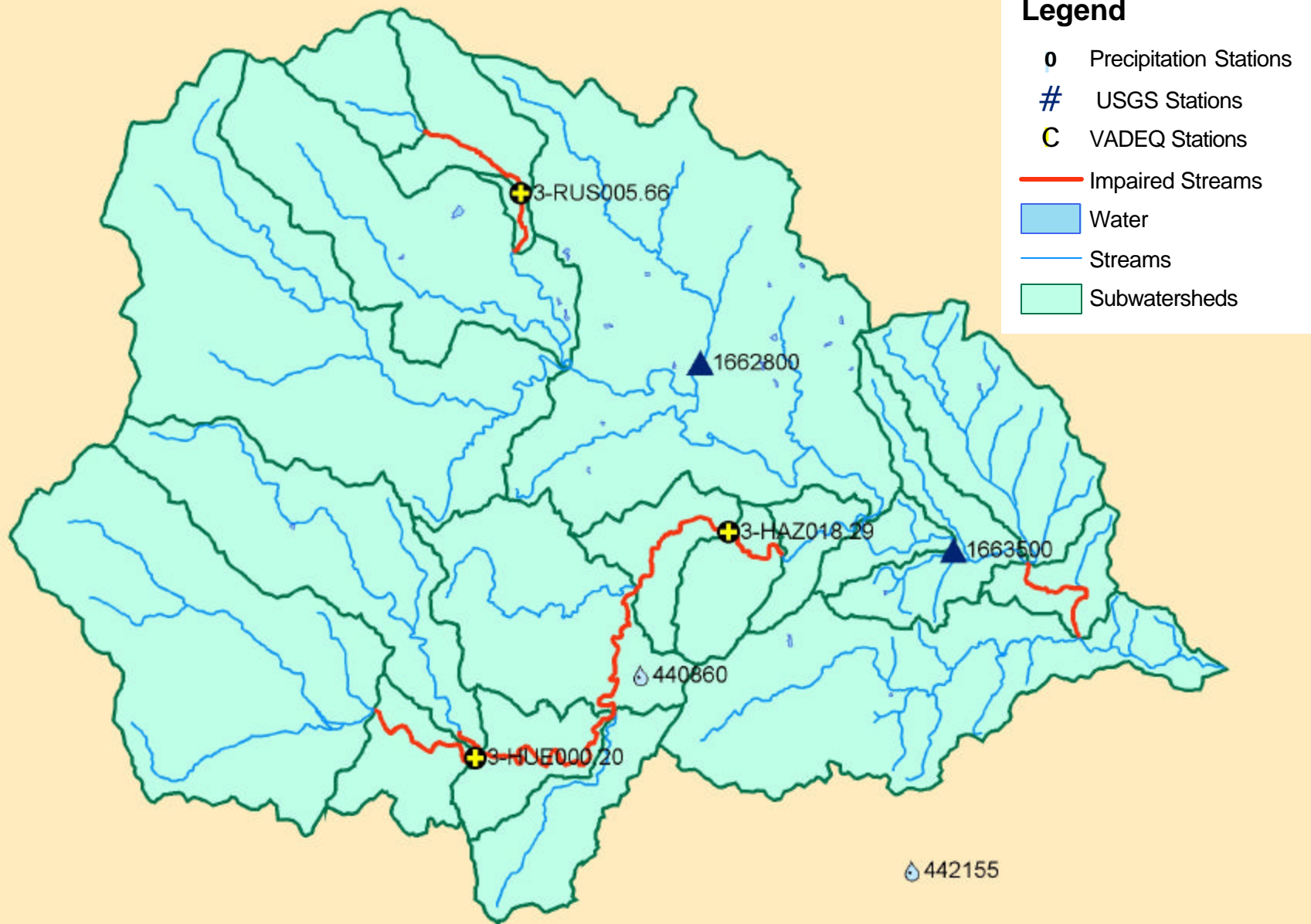


MODEL ACCURACY EVALUATION





MODEL ACCURACY EVALUATION





PRECIPITATION STATIONS

COOPID	Station Name	County	Timestep
442159	Culpeper Riverside CG	Culpeper	Hourly
446712	Piedmont Research St	Orange	Hourly
442155	Culpeper	Culpeper	Daily
440860	Boston 4 SE	Culpeper	Daily
443466	Gordonsville 3 S	Louisa	Daily
445050	Louisa	Louisa	Daily
440720	Big Meadows	Madison	Daily
445150	Madison	Madison	Daily
444692	Lake of the Woods	Orange	Daily
443462	Gordonsville FAA AP	Orange	Daily
447904	Somerset	Orange	Daily
443192	Fredricksburg Natl Pk	Spotsylvania	Daily



MONITORING STATIONS

Station ID	Waterbody	Station Type	Agency
01664000	Rappahannock River	Flow	USGS
01662800	Battle Run	Flow	USGS
01663500	Hazel River	Flow	USGS
3-RPP175.51	Rappahannock River	Bacteria	VADEQ
3-RUS005.66	Rush River	Bacteria	VADEQ
3-HUE000.20	Hughes River	Bacteria	VADEQ
3-HAZ018.29	Hazel River	Bacteria	VADEQ



ALLOCATION

1. Calculate existing loads for all sources
2. Create load reductions scenarios controlling anthropogenic sources first
3. Run model with scenarios
4. Calculate water quality standard (WQS) exceedance rate
5. Select scenario with 0% WQS exceedance rate
6. Calculate allocation loads for all sources



EXAMPLE ALLOCATION

Source	Existing Condition Load (cfu/yr)
Direct Deposition	
Straight Pipes	8.09E+13
Livestock	1.76E+12
Wildlife	5.93E+13
<i>Total</i>	<i>1.58E+14</i>
Land-based	
Residential	1.61E+14
Cropland	1.16E+13
Pasture	9.53E+15
Forest	2.95E+14
<i>Total</i>	<i>9.99E+15</i>



EXAMPLE ALLOCATION SCENARIOS

Scenario Number	Percent Reduction in Fecal Coliform Loading From Existing Conditions							% Exceedance of <i>E. coli</i> Standard	
	Straight Pipes	Livestock DD	Wildlife DD	Cropland	Pasture	Residential	Forest	Geometric Mean	Instantaneous
0	0	0	0	0	0	0	0	75	35
1	100	75	0	0	0	0	0	50	33
2	100	99	0	25	25	25	0	0	10
3	100	100	0	50	50	50	0	0	0



EXAMPLE ALLOCATION

Source	Existing Condition Load (cfu/yr)
Direct Deposition	
Straight Pipes	8.09E+13
Livestock	1.76E+12
Wildlife	5.93E+13
<i>Total</i>	<i>1.58E+14</i>
Land-based	
Residential	1.61E+14
Cropland	1.16E+13
Pasture	9.53E+15
Forest	2.95E+14
<i>Total</i>	<i>9.99E+15</i>

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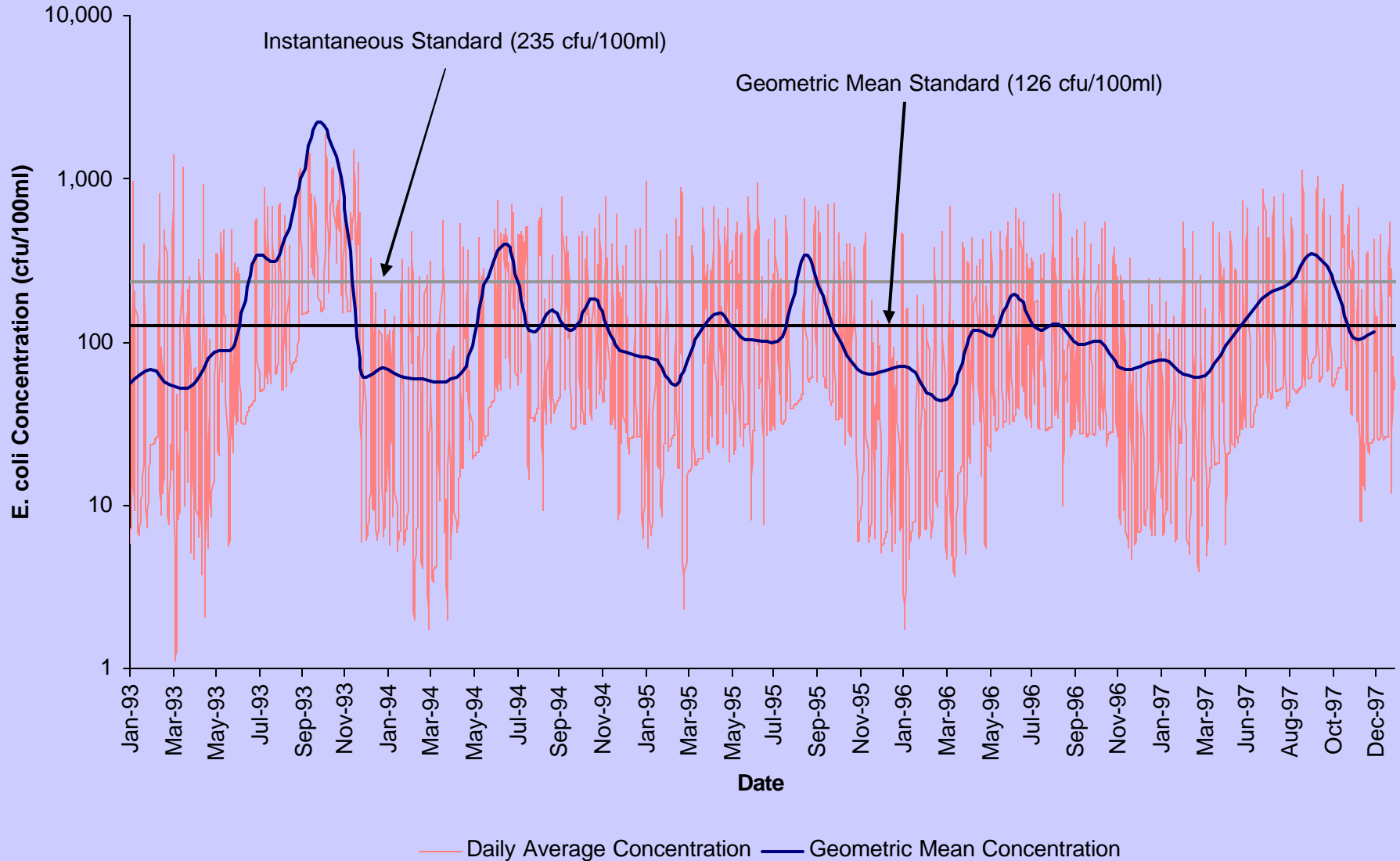
Scenario 3 Reduction (%)
100
99
0
50
50
50
0

=

Source	Allocation Condition Load (cfu/yr)
Direct Deposition	
Straight Pipes	0.00E+00
Livestock	1.76E+10
Wildlife	5.93E+13
<i>Total</i>	<i>5.93E+13</i>
Land-based	
Residential	8.05E+13
Cropland	5.80E+12
Pasture	4.77E+15
Forest	2.95E+14
<i>Total</i>	<i>5.15E+15</i>

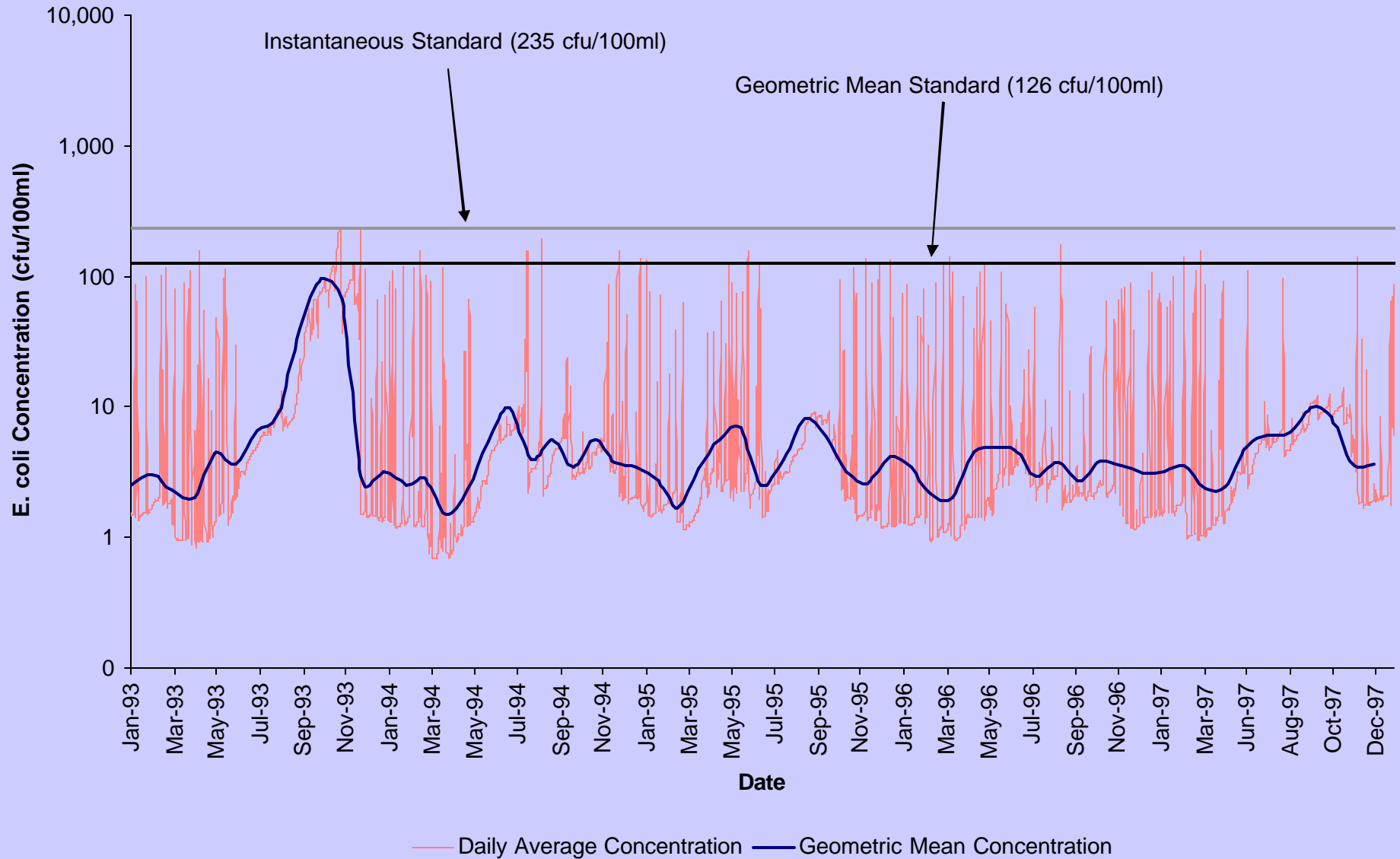


EXAMPLE EXISTING CONDITIONS





EXAMPLE ALLOCATION CONDITIONS





TIMELINE

- POLLUTANT SOURCE INVENTORY
 - Revisions based on feedback
 - Biosolids, straight pipes, failing septic systems estimates
- MODELING
 - Hydrology calibration and validation
 - Water quality calibration and validation

SECOND TAC MEETING

Presentation of modeling results and revisions to pollutant source inventory

- ALLOCATION DEVELOPMENT
 - Scenario development, assessment of scenarios, selection of allocation

THIRD TAC MEETING

Presentation of allocation scenarios

FINAL PUBLIC MEETING

Presentation of pollutant source inventory revisions, model results, allocation scenarios, and draft TMDL document



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